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Sleep quality in women seeking care for pelvic organ prolapse

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ABSTRACT

Objectives: To identify the prevalence of sleep disturbance in women seeking treatment for pelvic organ prolapse (POP) and identify correlates of poor sleep quality in this population by using a validated sleep scale.
Study design: This is a cohort study of female patients with pelvic organ prolapse.
Main outcome measures: Pittsburgh Sleep Quality Index (PSQI), Pelvic Floor Disorders Inventory (PFDI), and Pelvic Floor Impact Questionnaire (PFIQ) measures were completed. Demographic data, medical comorbidities, medications, and physical examinations were also recorded.
Results: 407 Women were enrolled. Analysis was performed on the 250 subjects who completed all PSQI components. Subjects were predominantly white, with a mean age of 61 ± 11 years and mean BMI of $28 \pm 5\,kg/m^2$. The majority (71%) had Stage III prolapse. Half ($N = 127$) had poor sleep quality (PSQI > 5). Women with poor sleep quality were younger, had more medical comorbidities, more pelvic floor symptoms, more nocturia, more depressive symptoms, and took more time to fall asleep. Factors associated with sleep quality were evaluated using multivariable linear regression models. Worse sleep scores were associated with each of the PFDI subscores (urinary, prolapse, bowel), depressive symptoms, severe nocturia symptoms, and number of comorbidities.
Conclusions: Poor sleep is prevalent in women with prolapse. Pelvic floor symptoms as measured by PFDI sub-scales, were associated with poor sleep quality. Future studies are needed to better understand how sleep disturbances may contribute to the impact of pelvic floor symptoms on quality of life.

1. Introduction

Sleep has a significant effect on overall health status and quality of life. Sleep disturbances are prevalent in the general population and can have serious health implications. Poor sleep can predispose older patients to increased falls, decreased concentration, memory changes, depression and cardiovascular disease [1]. In the general North American population, 17% of women reported sleep difficulties based on the 2002 NHIS annual survey question, "During the past 12 months, have you regularly had insomnia or trouble sleeping?" [2] Sleep disturbances are even more prevalent in midlife women; 38% of women aged 40–55 in the Study of Women's Health Across the Nation self-reported sleep difficulties associated with menopause [3]. Forty-six percent of a multinational cohort of women aged 40–59 reported poor sleep quality measured by the Pittsburgh Sleep Quality Index [4].

There has been a growing interest in the effects of lower urinary tract symptoms on sleep in both sexes. Nocturia has been shown to be strongly associated with sleep disturbance and poor quality of sleep [5]. Pelvic floor disorders include urinary incontinence, pelvic organ prolapse (POP), and fecal incontinence. Women seeking treatment for prolapse also frequently suffer from other pelvic floor symptoms including nocturia, pelvic pain, and bowel dysfunction. It has been estimated that women have an 11–19% lifetime risk for undergoing surgery for prolapse or incontinence; rates of asymptomatic POP are likely even higher, with estimates of 38–50% affected [6–9]. As the population ages, it is estimated that the rate of women seeking treatment for POP will double [10].

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POP has also been shown to affect many aspects of a woman's quality of life including her social, psychological, physical, sexual, body image and overall wellbeing [11,12]. Prior work by the authors demonstrated a high prevalence of depression in women with POP [13]. Fritel et al. found that self-reported symptoms of POP were associated with poorer quality of life in all domains of the Nottingham Health Profile including the sleep domain [14]. While studies exist examining sleep quality in men and women with urinary symptoms, to date there are no studies investigating sleep quality using a validated sleep scale in women affected by POP.

The objective of our study was to describe sleep quality in women presenting for care for pelvic organ prolapse. Specifically, we wanted to determine the prevalence of sleep disturbance in women seeking treatment for POP, to examine the relationship of pelvic floor symptoms to sleep, and identify correlates of poor sleep quality in this population by using a validated sleep scale. We hypothesized that sleep disturbances will be highly prevalent in a population of women with POP and associated with pelvic floor symptoms.

2. Material and methods

The University of Pittsburgh Institutional Review Board approved this study, and participants signed informed consent at time of enrollment. This study was a planned ancillary cross-sectional analysis of a larger prospective cohort study investigating mood symptoms in women seeking care for POP. Eligible women seeking care at the Women's Center for Bladder and Pelvic Health at the University of Pittsburgh Medical Center Magee-Womens Hospital were offered participation in the parent study. All women enrolled between August 2008 and December 2011 were included in this analysis.

2.1. Participants

Eligible participants included women answering "Yes" to one or both of the following questions from the Pelvic Floor Distress Inventory: (1) "Do you usually have a sensation of bulging or protrusion from the vaginal area?" and/or (2) "Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?" on their new patient intake forms. Included women had prolapse $\geq$ Stage II documented by POPQ examination. Following informed consent, subjects completed self-administered measures and the Personal Health Questionnaire-9 (PHQ9) screening via questionnaire, in-person or by phone with a trained research assistant [15]. Women unable to complete the informed consent process, participate in data collection, scoring <20 on the mini-mental status examination, or those women who were actively suicidal by our screening protocol were excluded.

2.2. Sleep quality measure

The Pittsburgh Sleep Quality Index (PSQI) is a validated self-reported measure of sleep quality and disturbances over the previous 1-month period [16]. Items 1–4 require free text responses and the remainder of items use a Likert scale. The PSQI consists of 18-items assessing various aspects of sleep quality and is scored as 7 component sub-scores and one global score. The sub-scales include: usual duration of sleep, nocturnal sleep disturbances, sleep latency, sleep quality, daytime dysfunction, sleep medication use, and sleep efficiency. The possible subscale scores range from 0 to 3 and the global scores range 0–21, with higher scores reflecting worse sleep quality. Poor sleep quality was defined using the cutoff of score greater than 5 and good sleep quality defined as a score of less than or equal to 5, as established by the scoring algorithm published by developers of the PSQI [16]. Proper scoring of the PSQI requires all 7 components.

2.3. Pelvic floor symptom measures

Pelvic floor symptom bother and impact on activities of daily living were assessed using the Pelvic Floor Disorders Distress Inventory (PFDI) and the Pelvic Floor Disorders Impact Questionnaires (PFIQ). The PFDI is a 46- item, self-reported, validated, condition-specific questionnaire that assesses presence or absence of pelvic symptoms as well as symptom-associated bother. It is composed of 3 sub-scales assessing urinary (Urinary Distress Inventory-UDI), pelvic (Pelvic Organ Prolapse Distress Inventory-POPDI) and colorectal symptoms (Colorectal-Anal Distress Inventory-CRADI). UDI and POPDI scores range from 0 to 300 and CRADI scores range 0–400. Higher scores indicate a higher number of and more bothersome symptoms. The PFIQ is a 93-item, self-reported, validated condition-specific quality of life measure that assesses the impact of urinary, prolapse, and bowel symptoms in relationship to activities of daily living. It is composed of 3 sub-scales ranging from 0-400 (Incontinence Impact Questionnaire (IIQ), Colorectal-anal Impact Questionnaire, and the POP Impact Questionnaire (POPIQ). Higher PFIQ scores indicate a greater impact of pelvic floor symptoms on functional ability [17]. Missing items are dealt with by using the mean from answered items only.

2.4. Other measures

The PHQ9 was used to measure depressive symptoms and is a 9 item self-report scale that correlates highly with the Structured Clinical Interview for DSM-IV [18]. The PHQ9 assesses how often symptoms have been bothersome over the previous 2 weeks, using a 4-point Likert scale, with higher scores indicating more severe depressive symptoms. Moderate to severe depressive symptoms are defined by score $\geq$10. The PHQ9 has been validated for use in primary care and obstetrics–gynecology outpatient clinics and provides the diagnosis of major depressive disorder and other depressive disorders. The Pelvic Organ Prolapse Quantification (POPQ) examination was used to assess prolapse and determine baseline stage [19]. Social problems and difficulties were assessed using the Social Problem Questionnaire. This is a validated self-report questionnaire consisting of 33 questions covering 11 domains including housing, occupation, finance, and relationships.

2.5. Statistical analysis

All analyses were performed using SAS 9.3 (SAS Institute, Cary, NC, USA) assuming statistical significance at $p < 0.05$. We conducted univariable comparisons of subject characteristics with good sleep quality (PSQI $\leq$ 5) and poor sleep quality (PSQI > 5) using Chi-square test for categorical data and t-test for continuous variables or Wilcoxon rank sum test for not normally distributed data. Linear regression models were constructed to evaluate the relationship between pelvic floor symptom scores and sleep outcome. Because it its skewed right distribution, the dependent variable sleep quality score (PSQI) was log transformed. Linear regression using log-transformed PSQI score as the dependent variable was chosen over logistic regression using dichotomized variable of poor sleep quality for superior statistical power given our sample size.

Several linear regression models were considered to examine the relationship of pelvic floor symptoms to sleep quality. Due to the skewed right distribution of the dependent variable, PSQI was log transformed. The independent variables, PFDI sub scales, PHQ9, number of comorbidities were not linearly related to log of PSQI, and were therefore categorized to develop the linear regression models. In order to have equally sized groups, these variables were

categorized by quartiles. Age was categorized into three groups as shown in Table 3. Model development was also influenced by the very strong and significant correlations between all the PFDI and PFIQ subscales. PFDI and PFIQ subscores were also significantly correlated to PHQ9, with correlation coefficients ranging 0.37–0.48, $p < 0.001$. In light of the strong correlations between PFDI subscales, separate models were developed for each subscale scores. The UDI assesses nocturia symptoms (question 27 of PFDI) and this question was used as a proxy for nocturia in the regression modeling with the POPDI and CRADI subscales. Factors associated with sleep quality were assessed and adjusted in the final multivariable models. Final models were also run using PHQ9 scores omitting question 3 regarding sleep disturbances. Interactions between all variables and multicollinearity across the variables were tested during multivariable regression model construction. Akaike information criterion and Bayesian information criterion were used to assess model fit.

3. Results

A total of 407 women enrolled in this study. One hundred fifty seven subjects did not complete one or more PSQI components, with the majority leaving free text items incomplete. The PSQI could not be scored for these subjects; therefore, analyses were performed on the 250 women with complete PSQI measures. All study variables were compared between women with complete PSQI and incomplete PSQI. No clinical or statistically significant differences were found.

Table 1 summarizes the population characteristics. The subjects were predominantly white, with a mean age of 61 ± 11 years and a mean BMI of 28 ± 5 kg/m^2. Seventy-three percent of subjects were married, and 65% were never smokers. The majority of subjects self-reported to be post-menopausal (83%). Most (71%) had Stage III POP, had experienced prolapse symptoms for a median of 2 years (range 1–5), 27% had attempted pessary use, and 69.6% had a prior prolapse repair. A third of women (37%) reported nocturia (defined as having answered "yes/moderate or severe" to question 27 of the PFDI, "Do you usually awaken during your normal sleeping to urinate?"). Subjects had a median of 5 medical co-morbidities and reported taking a mean of 6 ± 4 medications. Subjects reported a mean of 7.5 ± 1.6 h in bed and slept 6.6 ± 1.4 h per night.

About half ($N = 127$) of subjects had poor sleep quality based on a PSQI > 5 (Mean PSQI 6.4 ± 4.0). Table 1 also displays the characteristics of subjects by sleep quality status. Women with poor sleep quality were younger, had more medical co-morbidities, worse pelvic floor symptoms, higher depression scores, higher rates of nocturia and took significantly more time to fall asleep. In poor sleepers, all 7 PSQI components (sleep duration, sleep disturbance, sleep latency, daytime dysfunction, sleep efficiency, subjective sleep quality, and use of sleep medication) were significantly negatively affected.

The association of pelvic floor symptoms with good and poor sleep quality by age categories is presented in Table 2. Age is a known risk factor for poor sleep, however, in this cohort, poor sleepers were younger. To better describe changes by age, we examined poor sleep and pelvic floor symptoms in different age categories. Age categories were chosen to better differentiate women in the peri-menopausal transition from post-menopausal and elderly women. In women less than 65 years of age, PFDI and PFIQ subscale scores were consistently and significantly higher in poor sleepers compared to good sleepers except for the CRADI subscale, which was significant in the older subjects, and POPIQ.

Without adjusting for other variables, both PFDI and PFIQ subscale scores were found to have significant independent contributions to the models. When all three PFDI subscales were included in a model, the effects of each of the subscales are attenuated. Therefore, when creating final models with other significant variables we constructed separate models for each of the three PFDI subscales scores independently. Table 3 summarizes the linear regression models developed for each of the PFDI subscales (Models 1–3).

Interactions and multi-collinearity between variables were tested during regression model construction and no significant interaction effects were found except strong correlations between PHQ-9 and the pelvic floor questionnaire subscales. When separate multivariable models were developed using the sub-scales independently and adjusting for other variables (age, presence of social problem, menopausal status), number of comorbidities, depressive symptoms, nocturia, and each of the PFDI subscores were associated with higher PSQI scores (Models 1–3). The CRADI was significantly associated with increased PSQI scores at all score levels above 100. Models were also run using PHQ9 scored omitting question 3 regarding sleep disturbances. Depressive symptoms were found to be significant correlates for poor sleep even when sleep was removed from PHQ9 score. When examined independently none of the PFIQ sub-scales were significantly associated with sleep when adjusting for other variables.

4. Discussion

The primary finding of this research is that increased pelvic floor symptoms (urinary, pelvic organ prolapse, and bowel-related), as quantified by PFDI subscale scores, are associated with worse sleep as measured by PSQI scores. Interestingly, urinary symptoms as measured by the UDI and nocturia as measured by question 27 of the PFDI were not the sole contributors to poor sleep quality in women with pelvic floor disorders, and it appears that bowel and POP symptoms as measured by CRADI and POPDI measures respectively also play a significant role.

These findings are meaningful in the context of prior findings showing the long term adverse effects of poor sleep quality and sleep deprivation on quality of life as well as many areas of psychological and physical health. Adverse effects of poor sleep include but are not limited to effects on mood, cognitive health, immune function and cardiovascular health [20]. As pelvic floor disorders affect a quarter of women over the age of 20 [21], a large number of women are at risk for these symptoms. To our knowledge this is one of the few studies investigating sleep quality in women with pelvic organ prolapse. Fritel et al. described a significant univariate association between self-reported symptoms of vaginal bulging and the sleep domain of the Nottingham Health Profile, a general health-related quality of life instrument that includes 5 items on sleep [14]. Our study includes 250 women with known symptomatic POP and uses a validated sleep scale, allowing for the calculation of the prevalence of poor sleep quality in this population as well as exploration of predictors of poor sleep quality.

The prevalence of sleep disturbance in this population was higher that reported by Kravitz and similar to that reported by Blümel [3,4]. However, our findings are difficult to compare to findings of these mid-life studies due to differences in population ethnicity, method of sleep quality assessment, and lack of pelvic floor symptom assessment. Our findings suggest additional questions for exploration. It would seem intuitive that nocturia would impact sleep quality. A diminished sense of well-being and subjective poor sleep quality has been associated with nocturnal micturition [22]. Night time frequency has been shown to impact sleep and general health quality of life [23]. In this cohort, 36% of subjects reported nocturia as measured by responses to question 27 of the PFDI. Rates of nocturia differed significantly between good (35%) and poor sleepers (79%). The UDI assesses nocturia symptoms

Table 1
Characteristics by sleep quality.

	All women $N = 250$	Good sleep (PSQI ≤ 5) $N = 123$ (49%)	Poor sleep (PSQI > 5) $N = 127$ (51%)	p-Value
Race: caucasian, N (%)	244 (98)	119 (97)	125 (99)	0.168
Mean age (SD)	61 (11)	63 (11)	58 (11)	<0.001
Age group, N (%)				0.001
<55 years	72 (29)	25 (20)	47 (37)	
55–65 years	95 (38)	45 (37)	50 (39)	
>65 years	83 (33)	53 (43)	30 (24)	
Mean BMI (SD)	28 (5)	28 (5)	28 (5)	0.698
Martial status, N (%)	179 (73)	83 (69)	96 (76)	0.851
Smoking: never smoker, N (%)	162 (65)	82 (67)	80 (63)	0.683
Menopausal status: premenopausal, N (%)	42 (17)	12 (10)	30 (24)	0.003
Mean leading edge prolapse in cm (SD)	3 (2)	3 (2)	2 (2)	0.054
Median years with prolapse symptoms (IQR)	2 (0,4)	2 (0,5)	1 (1,4)	0.947
Mean number of medications (SD)	6 (4)	6 (4)	7 (4)	0.711
Median number of comorbidities (IQR)	6 (3,7)	4 (3,6)	6 (4,8)	<0.001
Social problem, N (with ≥1 problem), (%)	89 (36)	32 (27)	57 (45)	0.002
Median PFDI scores (IQR)				
UDI	171(125,223)	149 (108,200)	232 (155,232)	<0.001
POPDI	164 (113,212)	142 (100,175)	183 (135,232)	<0.001
CRADI	175 (100,240)	150 (83,221)	200 (138,250)	<0.001
Median PFIQ scores (IQR)				
UIQ	185 (145,260)	172 (139,217)	202 (158,300)	<0.001
POPIQ	179 (139,234)	160 (139,207)	197 (144,254)	<0.001
CRAQI	145 (133,213)	139 (133,176)	160 (133,261)	0.003
Median minutes to fall asleep (IQR)	15 (10,30)	10 (5,15)	30 (15,30)	<0.001
Median PSQI total (IQR)	6 (4,9)	4 (2,1)	9 (7,12)	<0.001
Median PHQ9 score (IQR)	3 (1,6)	1 (0,3)	5 (3,10)	<0.001
Nocturia, N^* (%)	91 (36)	30 (25)	61 (79)	<0.001

IQR: interquartile range.
* Defined as having answered "yes/moderate or severe" to question 27 of the PFDI.

(question 27 of PFDI), this question was used as a proxy for nocturia in the regression modeling. Interestingly, even while accounting for nocturia, each of the PFDI sub-scales were associated with worse sleep scores.

While the role of POP symptoms on sleep quality has not been well explored, there is some evidence of the link between functional bowel disorders and sleep disturbances. Cremonini et al. assessed sleep in over 3000 community living adults using the Insomnia Severity Index and found an association between functional bowel disorders and sleep disturbances [24]. Breckan et al. found a similar association between sleep and functional bowel symptoms in a Norwegian population. It is possible that the consistent association between CRADI scores and worse sleep is capturing this relationship [25]. As Jelovsek et al. reports, women with pelvic floor disorders have a high prevalence of functional bowel symptoms [26]. The CRADI also measures abdominal pain, back pain, and pain with defecation. It is also possible these pain symptoms contribute to the association between CRADI and poor sleep. Further studies are needed to better discriminate the relationships between specific pelvic floor symptoms and sleep disturbances. Further

Table 2
Median PFDI and PFIQ scores by age categories in good and poor sleepers (interquartile range).

Age group	Measure	Good sleep PSQI ≤ 5 $N = 25$ (35%)	Poor sleep PSQI > 5 $N = 47$ (65%)	p-Value[a]
<55 Years $N = 72$ (29%)	UDI	171 (118,225)	213 (248,167)	0.039
	POPDI	150 (88,175)	215 (150,245)	0.004
	CRADI	150 (100,238)	214 (138,275)	0.068
	UIQ	176 (133,228)	233 (155,309)	0.040
	POPIQ	165 (142,250)	175 (133,270)	0.008
	CRAIQ	133 (142,249)	218 (150,304)	0.006
55–65 Years $N = 95$ (38%)	Measure	Good Sleep PSQI ≤ 5 $N = 45$ (47%)	Poor Sleep PSQI > 5 $N = 50$ (52%)	p-Value[a]
	UDI	145 (125,188)	175 (150,213)	0.011
	POPDI	158 (100,183)	183 (139,224)	0.010
	CRADI	150 (100,208)	185 (125,246)	0.129
	UIQ	177 (138,228)	202 (157,267)	0.030
	POPIQ	160 (138,207)	197 (144,243)	0.058
	CRAIQ	138 (133,181)	152 (133,273)	0.040
>65 Years $N = 83$ (33%)	Measure	Good sleep PSQI ≤ 5 $N = 52$ (63%)	Poor sleep PSQI > 5 $N = 30$ (36%)	p-Value[a]
	UDI	139 (100,206)	175 (150,210)	0.120
	POPDI	136 (100,160)	167 (100,185)	0.079
	CRADI	100 (75,233)	198 (163,238)	0.027
	UIQ	153 (139,196)	195 (160,264)	0.020
	POPIQ	154 (140,192)	152 (133,194)	0.710
	CRAIQ	14 (133,176)	157 (137,202)	0.133

[a] p-Values are from Wilcoxon test.

Table 3
Linear regression models evaluating relationship of each PFDI subscale to poor sleep quality.

Model		Estimates	Standard Error	Geometric mean Ratio*, 95% CI	*p*-Value	Overall *p*-value
Model 1: UDI	UDI > 125 and ≤171	0.1820	0.1135	1.20 (0.96, 1.50)	0.1087	0.0768
	UDI > 171 and ≤223	0.2130	0.1145	1.24 (0.99, 1.55)	0.0627	
	UDI > 223	0.2880	0.1132	1.33 (1.07, 1.67)	0.0110	
Social Problem	Yes	−0.0688	0.0892	0.93 (0.78, 1.11)	0.4403	0.4405
Number comorbidities	>3 and ≤5	0.2863	0.1043	1.33 (1.09, 1.63)	0.006	0.0010
	>5 and ≤7	0.2254	0.1173	1.25 (1.00, 1.58)	0.0546	
	>7	0.4576	0.1153	1.58 (1.26, 1.98)	<.0001	
Age	>54 and ≤65	−0.1651	0.1246	0.85 (0.66, 1.08)	0.1851	0.3942
	>65	−0.1555	0.1303	0.86 (0.66, 1.11)	0.2328	
Depressive symptoms	5 ≤ PHQ9 < 10	0.4539	0.1016	1.57 (1.29, 1.92)	<.0001	<0.0001
	10 ≤ PHQ9 < 15	0.8318	0.1479	2.30 (1.72, 3.07)	<.0001	
	15 ≤ PHQ9 < 20	0.7981	0.2256	2.22 (1.43, 3.46)	0.0004	
	20 ≤ PHQ9	0.7222	0.2916	2.06 (1.16, 3.65)	0.0133	
Pre-menopausal status	Premenopausal	0.0441	0.1398	1.05 (0.79, 1.37)	0.7526	0.7526
Model 2: POPDI	POPDI > 113 and ≤164	0.0521	0.1070	1.05 (0.85, 1.30)	0.6264	0.0936
	POPDI > 164 and ≤212	0.2554	0.1104	1.29 (1.04, 1.60)	0.0206	
	POPDI > 212	0.2190	0.1222	1.24 (0.98, 1.58)	0.0731	
Social problem	Yes	−0.0741	0.0870	0.93 (0.78, 1.10)	0.3942	0.3945
Number comorbidities	>3 and ≤5	0.3227	0.1007	1.38 (1.13, 1.68)	0.0013	0.0006
	>5 and ≤7	0.2101	0.1159	1.23 (0.98, 1.55)	0.0699	
	>7	0.4433	0.1137	1.56 (1.25, 1.95)	<.0001	
Age	>54 and ≤65	−0.1102	0.1218	0.90 (0.71, 1.14)	0.3655	0.6570
	>65	−0.100	0.1296	0.90 (0.70, 1.17)	0.4404	
Depressive symptoms	5 ≤ PHQ9 < 10	0.3936	0.0999	1.48 (1.22, 1.80)	<.0001	<0.0001
	10 ≤ PHQ9 < 15	0.7412	0.1454	2.10 (1.58, 2.79)	<.0001	
	15 ≤ PHQ9 < 20	0.7083	0.2229	2.03 (1.31, 3.14)	0.0015	
	20 ≤ PHQ9	0.5741	0.2836	1.78 (1.02, 3.10)	0.0429	
Pre-menopausal status	Premenopausal	0.1416	0.1369	1.15 (0.88, 1.51)	0.3009	0.3014
Nocturia	Awaken, but bother not at all	−0.1931	0.1378	0.82 (0.63, 1.08)	0.1612	0.0180
	Awaken, bother somewhat	0.0487	0.1095	1.05 (0.85, 1.30)	0.6566	
	Awaken, bother moderately	0.0586	0.1228	1.06 (0.83, 1.35)	0.6336	
	Awaken, bother severe	0.2959	0.1218	1.34 (1.06, 1.71)	0.0151	
Model 3: CRADI	CRADI > 100 and ≤175	0.2850	0.1109	1.33 (1.07, 1.65)	0.0102	0.0114
	CRADI > 175 and ≤239	0.3565	0.1128	1.43 (1.14, 1.78)	0.0016	
	CRADI > 239	0.2558	0.1221	1.29 (1.02, 1.64)	0.0361	
Social problem	Yes	−0.0454	0.0882	0.96 (0.80, 1.14)	0.6070	0.6071
Number comorbidities	>3 and ≤5	0.3167	0.1028	1.37 (1.12, 1.68)	0.0021	0.0021
	>5 and ≤7	0.1436	0.1194	1.15 (0.91, 1.46)	0.2293	
	> 7	0.3779	0.1138	1.46 (1.17, 1.82)	0.0009	
Age	>54 and ≤65	−0.1264	0.1237	0.88 (0.69, 1.12)	0.3068	0.5924
	>65 and ≤69	−0.1023	0.1304	0.90 (0.70, 1.17)	0.4326	
Depressive symptoms	5 ≤ PHQ9 < 10	0.4165	0.1000	1.52 (1.25, 1.85)	<.0001	<0.0001
	10 ≤ PHQ9 < 15	0.7575	0.1475	2.13 (1.60, 2.85)	<.0001	
	15 ≤ PHQ9 < 20	0.7462	0.2180	2.11 (1.38, 3.23)	0.0006	
	20 ≤ PHQ9	0.6323	0.2797	1.88 (1.09, 3.26)	0.0238	
Pre-menopausal status	Premenopausal	0.1493	0.1354	1.16 (0.89, 1.51)	0.2701	0.2707
Nocturia	Awaken, but bother Not at all	−0.2050	0.1402	0.81 (0.62, 1.07)	0.1437	0.0322
	Awaken, bother Somewhat	0.0373	0.1126	1.04 (0.83, 1.29)	0.7408	
	Awaken, bother Moderately	0.0061	0.1239	1.01 (0.79, 1.28)	0.9608	
	Awaken, bother severe	0.2688	0.1257	1.31 (1.02, 1.67)	0.0324	

§ Variables were categorized by quartiles.
* Geometric mean Ratio = *exp* (estimates): the exponentiated coefficient estimate represents the geometric mean ratio to the reference group.
The interpretation of the exponentiated coefficient estimate = *exp* (0.3726) = 1.45 is as follows: PSQI is 45% higher for the group [125 < UDI ≤ 171] than for the reference group [UDI ≤ 125] ($p = 0.0027$). CI = confidence interval = (lower bound, upper bound).

characterization of the pelvic floor symptoms that contribute most to poor sleep quality will help clinicians identify patients most at risk for poor sleep.

While increased PFDI scores increased the likelihood of worse sleep, PFIQ scores did not prove to be predictors for sleep quality in our modeling. PFIQ scores were highly correlated with depressive symptoms (PHQ9 score). In our modeling, PHQ9 scores were very strongly associated with poor sleep. This is not surprising, as poor sleep is not only a characteristic feature of depression, but it is a risk factor for the development of new and recurrent episodes of depression [27,28]. Individuals who report poor sleep quality are at higher risk for depression throughout their lifetime [28]. The relationship we identified between PFIQ scores and depression is consistent with our prior finding in which worse PFIQ scores were independently associated with an increased risk of depressive symptoms in women seeking care for pelvic organ prolapse [13]. The effect of PFIQ scores on sleep quality was attenuated in our models, which may in part be due to the fact that PFIQ measures functional impact, as opposed to symptoms. Sleep may be an important missing clue to help explain the relationship of depressive symptoms and pelvic floor disorders.

Another interesting finding of our study was that younger and peri-menopausal women were more likely to have poor sleep. In these groups pelvic floor symptoms were significantly different between good and poor sleepers. Sleep has been described as deteriorating with age, however the extent to which this is directly related to aging is unclear [29]. A study of 1279 Finnish midlife women, Polo-Kantola et al. report one quarter of women are dissatisfied with their sleep. The greater the sleep disturbance the worse health related quality of life [30]. Blümel et al. report an increase of

poor sleep quality both with age and with menopause in women aged 40–59 [4]. Symptoms of hot flushes and night sweats were not queried in this cohort, it is plausible that these symptoms might contribute to poor sleep in younger women. In our model, age and menopausal status were, however, not associated with worse sleep scores. Data from the SWAN study demonstrates that women in the menopausal transition experience many symptoms including sleep problems that decreased their overall quality of life. The relationship between age or peri-menopausal status and pelvic floor symptom bother is unclear. In describing prolapse severity and symptom bother in women planning surgery for prolapse, Fitzgerald et al. found that women presenting for surgery with Stage II prolapse were younger [31]. As hypothesized by those authors, younger women may have a lower threshold for symptom bother and quality of life impact. This may also translate to a heightened effect of symptoms on sleep. Our cohort is older and may have a smaller distribution and less variability in age to capture precise effects of age.

Our study has several limitations. While our analysis included a large sample size, a portion of the total sample size was missing complete PSQI data and could not be included. The subjects were recruited from a somewhat homogenous population of women seeking care at tertiary referral. Subjects had symptomatic and demonstrable pelvic organ prolapse. We did not assess for menopausal symptoms of hot flushes or night sweats. In addition, the findings of this study may not be able to be generalized to a more diverse population of women with pelvic floor disorders including women with less severe prolapse or women who have not chosen to seek care.

This study found that pelvic floor symptoms increase the likelihood of poor sleep quality. Two small case reports have reported on the improvement in subjective sleep quality in women undergoing prolapse surgery using health related quality of life measures [32,33]. We have previously shown an improvement in depressive symptoms after prolapse surgery [13]. Studies are needed to ascertain whether the improvement of pelvic floor symptoms and depressive symptoms following treatment translates into a similar improvement in sleep quality and whether those with poor sleep have less improvement in pelvic floor symptoms after treatment.

In conclusion, this research indicates that there is a high prevalence of sleep disturbance in women seeking care for pelvic organ prolapse. In this population of women seeking care for pelvic organ prolapse, pelvic floor symptoms are associated with sleep quality. More research in this area is needed to better clarify the relationship between sleep and pelvic floor disorders, understand how sleep disturbances contribute to the impact of pelvic floor symptoms on quality of life, and the importance of sleep as quality of life outcome in the treatment of pelvic floor disorders.

Conflict of interest statement

The authors report no conflicts of interest.

Contributors

Ghetti: protocol/project development, data analysis, manuscript writing;
Lee: data analysis, manuscript writing;
Oliphant: data analysis, manuscript writing;
Lowder: data analysis, manuscript writing.

Competing interests

The authors declare no conflict of interest.

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